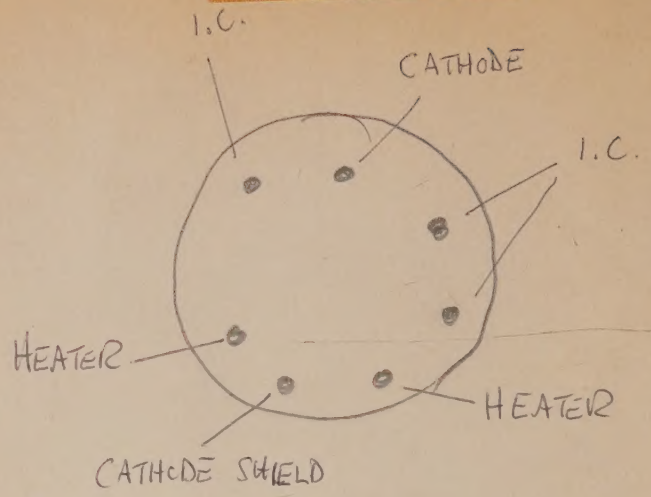
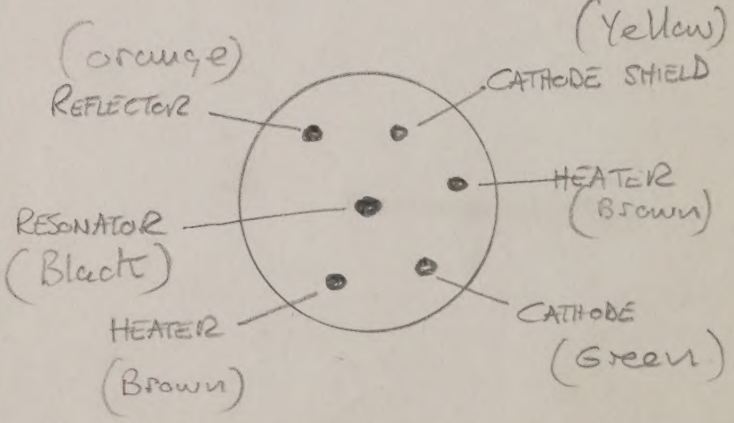
PATENT DEPT.

ELLIOTT



View from underside of tube
R9696

ELLIOTT B700 KLYSTRON P.S.U.



Front Panel output Socket Connections

HANDBOOK OF THE ELLIOTT

LOW VOLTAGE KLYSTRON POWER UNIT

TYPE B.700 /772

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HANDBOOK OF THE ELLIOTT
LOW VOLTAGE KLYSTRON POWER UNIT
TYPE B.700

1. INTRODUCTION

1.1 General Description

This power unit is designed to supply klystrons having accelerating fields between 200 and 400 volts and retarding fields up to 720 volts. The instrument will provide cathode currents up to 45 milliamps and, in addition, smoothed variable d.c. supplies for the klystron heaters.

An internal oscillator covering the frequency range 400 c/s to 4 kc/s provides a square wave signal for amplitude modulation at the cathode or reflector and a triangular wave signal for frequency modulation at the reflector.

The instrument is suitable for use with supply mains from 180 to 270 volts, 40 to 60 c/s.

1.2 Method of Construction and Layout of Sub-units

The standard method of construction used for this instrument is the result of over a year's work in conjunction with an industrial design consultant. The case has clean modern lines with a recessed front panel to protect the controls from accidental damage. There are no panel rails or other projections to get in the way of fingers and connectors but at the same time the instrument is easy to carry. Physical strength, adequate ventilation and ease of servicing have all been considered and the solutions incorporated into the design.

The unit principle has been adopted for the electronic circuits; standard sub-units designed to perform specific functions are screwed to a central framework to which the front panel and its surrounding bezel are also attached. The short sub-unit chassis are very sturdy and are arranged so that the components face outwards from the framework: this greatly simplifies fault finding and servicing. The central framework also serves as support for the back panel, a simple "wrap-around" casing and the feet on which the instrument stands. As a result of this method of construction, the instruments are very strong and can be stacked one upon the other (from floor to ceiling if necessary) without risk of damage.

Stacking does not affect ventilation. Air inlets are provided in the bottom of the casing, under the front panel and at the bottom of the back panel. There are outlets at the top of the front and back panels and at the sides. The layout concentrates the majority of the heat in the centre of the instrument; air is drawn in immediately below this region and escapes through the holes above the sub-unit chassis. Secondary ventilation also occurs between the sub-unit chassis and the outer casing. There are no ventilation holes in the top to be blocked by casually laid down papers, etc, and it is not normally possible to interfere with ventilation to any serious extent.

Removal of the back panel exposes the two power supply chassis and the transformer tapping arrangements. The casing can normally be removed within two minutes by following the instructions in Section 6.1.

The order in which the individual sub-unit chassis are arranged on the main framework is as follows: on the left-hand side, looking from the rear, is the stabiliser unit; at the back, from left to right are the two power unit chassis, the square wave generator and the cathode modulator and on the right-hand side is the amplifier unit (nearest the rear) and a small rectifier unit which produces the d.c. supply for the klystron heaters.

2. DETAILED DESCRIPTION

2.1 760 Volt Stabilised Supply

Two standard rectifier sub-units are supplied in parallel from the a.c. mains and each provides some heater supplies and a 450 volt smoothed d.c. output (see Figs. 1 and 2). The two d.c. outputs are connected in series to give 900 volts which is then stabilised at 760 volts by the stabiliser unit. This comprises a sampling network, a cascode error amplifier and two series control valves in parallel. The ripple on the 760 volt line is normally about 10 millivolts peak-to-peak at twice the supply frequency. The nominal voltage of the supply can be varied by $\pm$ 10% without exceeding the dissipation of the control valves or losing stabilisation.

It should not be necessary to change the transformer tappings often, but when desirable it can be done by removing the back cover, unsoldering the line side of the supply lead and resoldering it to the appropriate tapping on the left-hand unit (see Fig. 3). This unit also acts as an autotransformer supplying the second power unit so that no further changes of tapping are required.

2.2 Amplifier Unit

The amplifier is a screened unit situated on the right-hand side of the main chassis, viewed from the rear. The circuit diagram is given in Fig. 4. A double triode is connected as two cathode followers, one follower providing a low impedance voltage for the screen of the pentode V3 in the cathode modulator unit and the other providing a reference voltage for the klystron cathode and a low impedance output to the cathode shield. From this point also, an amplifier is connected to the negative line. This comprises a pentode with a resistive anode load and negative feedback from anode to grid. Its output provides a low impedance supply to the klystron reflector. The amplifier has a maximum gain of about 10 and a bandwidth from 1 c/s to 100 kc/s when supplied from a low impedance source. A socket on the front panel is linked through the reflector modulation selector switch and a potentiometer to its input to provide external reflector modulation facilities, in addition to the internal square wave modulation and internal frequency modulation facilities incorporated in the equipment. The reflector voltage is adjusted by varying the bias on this valve by means of another potentiometer situated on the front panel. A long time-constant in this network gives it a rather sluggish response which must be taken into account when adjusting the reflector voltage. The ripple on the reflector supply is about 20 millivolts peak-to-peak in the c.w. condition.

The minimum reflector voltage corresponds to the amplifier being cut off and as the anode load is connected effectively to the klystron cathode potential it is not normally possible for the reflector to rise positively with respect to the cathode so that there is no risk of damage to the klystron due to the reflector taking excessive beam current. Over-modulation will result only in a change in the mean d.c. level of the reflector voltage without change to the upper and lower limits.

2.3 Square Wave Generator

This consists of two pentodes, electron coupled and supplied from a 300 volt stabilised line based on the -760 volt supply (see Fig. 5). The output from one pentode, suitably attenuated, is coupled to the synchronising output socket and provides a square wave of some 20 volts peak-to-peak amplitude at a low impedance and with sharp edges. The other pentode has a similarly attenuated output which is available to the internal modulator. This valve has an integrated output providing a triangular waveform which is used for frequency modulation of the reflector. A potentiometer situated on the front panel provides variable charging rates for the multivibrator coupling capacitors, enabling the

oscillator frequency to be varied between 400 and 4,000 c/s.

2.4 Cathode Modulator

This sub-unit (Fig. 5) consists essentially of a d.c. coupled White cathode follower. The upper element of this arrangement is a double triode V2,one half of which is used to handle the positive-going edges and the top of the output waveform. The second half of this valve (V2b) is used to establish precisely the negative limit of the waveform corresponding to the condition of oscillation of the klystron. The lower element of the White cathode follower consists of a pentode V3 which handles negative-going pulse edges and provides the current demanded by the klystron. V1a is the modulation amplifier and V1b and R5 and R6 form an anode follower circuit which limits the top of the output waveform.

The klystron cathode voltage is therefore determined solely by the circuit of V2a when oscillating and by V1a when not oscillating and the modulation signal applied to the system only controls the edges of the pulse. Once this signal exceeds the minimum amplitude, its shape has no further influence on the modulator. This circuit provides very fast edges, with a rate of about 200 volts per microsecond, to the klystron pulse. Where a connection is available, the focussing electrode (cathode shield) of the klystron can be held from a low impedance source within 1 volt of the correct working cathode voltage for the klystron. When the cathode potential rises positively, the beam is defocussed and the current is reduced by the resulting negative bias on the cathode shield until oscillation becomes impossible. This makes for a smaller modulation waveform than would otherwise be necessary and consequently faster edges.

3. OPERATION

3.1 Preliminary Checks

The instrument leaves the works set up for operation from supply mains from 220 to 260 volts. Before plugging in, check the supply voltage and, if it falls outside these limits, remove the back panel and unsolder the line side of the mains supply lead from the 240 volt tapping on the power supply sub-chassis (see Fig. 3). Resolder to the appropriate tapping. The transformer is auto-connected to the second transformer on the adjacent chassis and the connections to this latter transformer require no adjustment.

3.2 Klystron Connections

Before switching on, check the connections to the klystron electrodes and wire to the appropriate terminals on the back of the unit or connect to the socket on the front panel (see Fig. 6). Screened leads should be used for the cathode and reflector connections.

A number of klystrons bring out the beam focussing electrode as a separate pin on the valve base. The instrument is designed to take advantage of this by defocussing the beam during modulation. Normally, the cathode and cathode shield are operated at the same potential, but during the "off" cycle of the modulation waveform the accelerating field is reduced and the simultaneous application of a negative bias to the focussing electrode results in a reduction of beam current and defocussing.

In some valves a focussing electrode is internally connected to the cathode; with these, a rather larger modulation waveform is required and the cathode shield terminal is not used.

The unit is designed to be operated with the resonator earthed and with the klystron heaters not connected to the cathode. The heater supply is linked to the cathode through a 100 kilohm resistor (in the cathode modulator). The operation will not, however, be impaired if the heater and the cathode are joined together at the klystron. In this case, however, the heater current must not be allowed to flow along the cathode lead which should be run back separately to the power unit as otherwise the voltage drop due to the heater current along the lead will cause 100 c/s modulation of the klystron. Under no circumstances should any of the terminals, other than one of the heaters, be connected to any other as damage could result.

3.3 Operating Conditions

The power unit provides highly stabilised supplies for the accelerating and retarding fields of reflex klystrons. Supply frequency ripple at the cathode and reflector connections is normally less than 10 millivolts peak-to-peak. The meter on the left-hand side of the front panel can be used to measure the mean cathode voltage, the mean cathode current, the heater voltage and the heater current, the required range being selected by the right-hand switch below the meter. High-speed pulse modulation can be applied by switching the accelerating field from the c.w. condition to a lower value at which oscillation cannot occur. Two preset controls are located on the front panel, the upper one of which controls the cathode voltage for c.w. operation and the lower one

controls the cathode voltage for the quiescent condition.

The reflector supply is continuously monitored on the meter on the right-hand side of the front panel and the retarding field is varied by means of a knob situated just beneath it and to the left. This supply is provided from an amplifier with a low output impedance, due to negative feedback, but a high d.c. resistance. As a result, it is impossible for the klystron reflector to take excessive beam current either by misadjustment of the controls or by over-modulation.

The heater voltage is controlled by a preset rheostat situated in the centre of the front panel. If the klystron does not load the supply sufficiently to reduce the voltage to the required value, an additional resistive load can be connected to the terminals on the back of the unit.

3.4 Initial Setting-up

(a) Turn the accelerating field upper and lower limit preset controls and the heater voltage preset control fully anti-clockwise, i.e. to the minimum voltages. THESE STEPS ARE MOST IMPORTANT AS DAMAGE CAN BE DONE TO A VALVE BY WRONG INITIAL SETTINGS.

(b) Set the meter selector switch to "heater volts".

(c) Set the cathode modulation selector to the "c.w." position, the reflector modulation selector to "off" and turn the reflector modulation amplitude control fully anticlockwise.

(d) Connect to the mains supply and switch on. After one minute, adjust the heater voltage to the correct working value and check the heater current.

(e) Set the meter switch to "cathode volts" and adjust the upper limit preset control to the correct c.w. condition for the klystron.

(f) Recheck the heater voltage and readjust if necessary.

3.5 C.W. Operation

Adjust the reflector voltage for maximum power output of the klystron at the desired frequency. Note that the highest power output is usually obtained in the highest reflector voltage mode available. The damping of the reflector voltage meter is controllable

by the amplitude potentiometer and can be varied up to about 2 seconds' time-constant.

3.6 Amplitude Modulation

Switch the cathode modulation selector to the "standby" position, vary the reflector voltage over the full range and check the klystron for any evidence of oscillation. The optimum setting for the lower limit preset control is just below the value at which no oscillation can be detected in the klystron at any value of reflector voltage.

Now switch to the "internal modulation" position. The cathode voltage reading will fall to a value half-way between the upper and lower limits. The modulation frequency is controlled by the knob in the centre of the panel, at the top, and if a selective amplifier is being used this must be adjusted to the resonant frequency of the equipment.

The instrument is designed to provide facilities for externally-generated pulse modulation. It responds in about 0.5 microsecond and will handle pulses of less than 1 microsecond duration. The mean pulse amplitude should be positive and in excess of 10 volts. The input impedance is approximately 1 megohm in parallel with 150 picofarads and for short pulses a low impedance source is necessary. Set the cathode modulation selector switch to the "external" position and connect the pulse generator to the cathode modulation input socket on the front panel.

If it is desired to amplitude modulate by switching the reflector voltage rather than that of the cathode, this can be done by applying a square-topped waveform to the reflector modulation amplifier. This amplifier has a frequency response which is limited at about 100 kc/s and the circuit is unsuitable for high-speed modulation. The amplifier has a maximum gain of about 10 which is controlled by the amplitude potentiometer. To set up for reflector modulation, proceed as follows: set the cathode modulation selector to the "c.w." position and the reflector modulation selector at either "internal square" or "external" as required. At the desired radio frequency select a suitable klystron mode and, by observing the points at which oscillation ceases, determine the reflector voltage width of the mode. Now apply the modulating signal with a peak-to-peak amplitude of about two thirds of this value. Adjust the reflector voltage to the positive side of the mode if the positive-going pulses are required or to the negative side of the mode if the negative-going pulses are required.

3.7 Frequency Modulation

The reflex klystron is frequency-sensitive to both accelerating and retarding fields. Frequency modulation is possible on the reflector with excursions up to a few megacycles per second without serious loss of power. For display purposes a uniformly time-varying waveform such as a triangular wave is required. To set up for frequency modulation proceed as follows: set the cathode modulation selector to the "c.w." position, set the reflector modulation selector to either "external" or "internal f.m." and turn the reflector modulation amplitude control fully anticlockwise. Adjust the reflector voltage for maximum oscillation in the desired mode and without further adjustment increase the amplitude control until the required frequency excursion is obtained. As set up, the modulating waveform will be disposed symmetrically about the peak of the reflector mode and frequency modulation will be at a maximum with amplitude modulation at a minimum.

3.8 Combined Amplitude and Frequency Modulation

In some cases where only a very weak signal is available from the equipment, it may be desirable to employ a high gain a.c. amplifier in order to display the frequency-dependent characteristics of the circuit. This may be done by simultaneously applying square wave modulation to the cathode and a triangular or saw-tooth waveform to the reflector. The resultant output from the klystron will consist of r.f. pulses which are frequency modulated. The amplitude/frequency characteristics of the circuit will then be superimposed upon the signal pulses from the equipment. If the time-base of a cathode-ray oscilloscope is used for the frequency modulating signal and made to run very much slower than the square wave, the effect on the display will be of two dotted lines. One of these will represent the base line and the other the amplitude/frequency characteristic of the circuit.

4. SPECIFICATION

4.1 Input

Mains supply	:	180 to 270V, 40 to 60 c/s
Stabilisation range	:	± 8% on nominal setting

4.2 Output

4.2.1 Cathode Supply

Voltage range	:	200 to 400V

Maximum current	:	45 mA
Ripple	:	less than 3 mV r.m.s.

4.2.2 Reflector Supply

Voltage range	:	from cathode voltage to -720V
Maximum current	:	3 mA
Ripple	:	less than 5 mV r.m.s.

4.2.3 Heater Supply

Voltage range	:	2 to 8V
Maximum current	:	2A
Ripple	:	less than 50 mV r.m.s. at 6.3V,1 amp.

4.2.4 Cathode Shield Supply

Voltage range	:	200 to 400V
Maximum current	:	5 mA
Ripple	:	less than 3 mV r.m.s.

4.3 Modulation

4.3.1 Internal Oscillator

Mark/space ratio	:	0.9 to 1.1
Modulation frequency range	:	400 to 4,000 c/s
Frequency stability	:	better than 1%, long term better than 0.2%, short term
Square wave synchronising output	:	20V peak-to-peak, open circuit 10 mA peak-to-peak, short circuit
Triangular wave $\frac{dV}{dt}$	:	50V/msec

4.3.2 Cathode Modulation

Peak charging current for external capacities:

negative-going edges	:	150 mA, less klystron current
positive-going edges	:	40 mA, less klystron current

Internal capacity of cathode circuit	:	150 pF
Differentiating time-constant of input circuit	:	0.1 sec
Input impedance	:	1 megohm 50 pF

4.3.3 Reflector Modulation

(i) External

Amplifier frequency response	:	1 c/s to 100 kc/s
Maximum voltage amplification factor	:	10
Input impedance	:	100 kilohms 150 pF
Output impedance	:	2 kilohms

(ii) Internal Frequency Modulation

Waveform	:	triangular
Maximum slope	:	500V/msec
Output impedance	:	2 kilohms

(iii) Internal Square Wave

Maximum amplitude	:	200V peak-to-peak, open circuit
Output impedance	:	2 kilohms

(iv) Off

Meter damping	:	0.1 to 2 sec

5. TEST SPECIFICATION

5.1 Checks with Voltmeter

(a) Remove instrument case (see Section 6.1) and set the unit upside down.

(b) Connect an 8.2 kilohm, 15 watt, wire-wound resistor between the cathode output terminal and the earth terminal on the

rear of the instrument.

(c) Connect a model 8 Avometer with its positive to earth and its negative to the -760 volt line on the stabiliser chassis. Use the 1,000 volt range of the Avo.

(d) Switch on. Check the range of adjustment of the stabiliser voltage control. This should nominally be 650 to 850 volts. Set it to 760 volts.

(e) Set the cathode modulation selector to the "c.w." position, the cathode voltage to 400 volts and measure the voltage drop across the 3.9 kilohm resistor (R18) on the modulator chassis. Adjust the standing current control (RV1) on the right-hand side of the chassis to give a voltage drop of 20 volts. Set the upper limit control to its maximum.

(f) Change the modulation selector to the "standby" position. Adjust the lower limit control over its full range. This should be from less than 200 volts to more than 400 volts. At the same time, check the meter calibration against the Avo connected to the terminals at the rear. Set the lower limit control to minimum.

(g) Switch the cathode modulation selector to the "c.w." position. Connect the Avo between the reflector and cathode shield terminals and check the range of adjustment of the reflector voltage with the upper limit control set at 200 volts. This range should by 0 to 480 volts. Check the calibration of the meter.

(h) Check the supply to the square wave generator. This should be 470 volts.

(i) Check the supply to the screen of the 6CH6 (V3) on the modulator unit (tag 3). This should be 150 volts.

(j) Check the voltage difference between the cathode and the cathode shield (pin C). This should be about 1 volt.

(k) Check the d.c. voltages on the heaters with selector at "c.w." and upper limit set to 250 volts. These should be as follows:

heater 1	:	200 volts (on the amplifier unit)
heater 2	:	250 volts (on the modulator unit)

heater 3 : 460 volts (on the modulator unit)

heater 4 : 760 volts (on the amplifier unit)

heater 5 : 0 volts (on the stabiliser unit)

5.2 Checks with Cathode-ray Oscilloscope

(a) Check that the ripple on the -760 volt line is not greater than 20 millivolts peak-to-peak.

(b) Observe the trace and check for excessive jumping which indicates random fluctuations in the output voltage.

(c) Set the cathode modulation selector switch to the "c.w." position and check the ripple on the klystron cathode when set at 400 volts. This should not be more than 7 millivolts peak-to-peak. Examine the trace for random jumping and loss of control due to overloading. Check that the amplitude of the differentiated spikes is not greater than 30 millivolts.

(d) Measure the ripple on the reflector terminal. This should not be more than 30 millivolts peak-to-peak with the reflector voltage set at 200 volts. The differentiated spikes should not be greater than 30 millivolts in amplitude. Switch the cathode modulation selector to the "internal modulation" position and check that the differentiated spikes are not greater than 1 volt. Set the reflector modulation amplitude control to maximum and short circuit the reflector modulation input socket. Examine the trace for jumping which indicates leaking coupling capacitors. In this condition, the ripple should not exceed 60 millivolts peak-to-peak.

(e) Set the cathode modulation selector to the "standby" position and adjust the lower limit control to 200 volts. Switch the selector to the "c.w." position and adjust the upper limit control to 400 volts. Connect the oscilloscope across the 8.2 kilohm load. Set the modulation selector to the "internal modulation" position and carry out the following checks:

(i) Check that the waveform is a square wave of 200 volts amplitude with sharp edges.

(ii) Check the overshoot of the edges; the negative-going edge should have less than 5 volts overshoot

and the positive-going edge should have less than 20 volts overshoot.

(iii) Check the slope of the edges; both the negative-going edge and the positive-going edge should be less than 2 microseconds.

(iv) Check the pulse lengths at maximum p.r.f.; both the positive and negative half-cycles should not be more than 125 microseconds and the difference between them should not be more than 20 microseconds.

(v) Check the pulse lengths at minimum p.r.f.; both the positive and negative half-cycles should not be less than 1250 microseconds and the difference between them should not be more than 200 microseconds.

(f) Check the synchronising output. It should not be less than 20 volts in amplitude and the edges should be sharp.

(g) Check the cathode shield waveform. It should not have more than 10 millivolts peak-to-peak ripple nor spike amplitudes greater than 200 millivolts.

(h) Check the external cathode modulation. Switch to the "external modulation" position of the cathode modulation selector and link the synchronising output and cathode modulation input sockets. Observe the cathode waveform. It should be as in (i), (ii) and (iii) in (e) above.

(i) Check the reflector modulation. Set the modulation amplitude control for 200V square wave. Couple the oscilloscope to the reflector terminal through a 5 picofarad capacitor in parallel with a resistor whose value should be chosen to suit the frequency response of the oscilloscope. Check the reflector modulation square waveform. At 4 kc/s it should be a good square wave with edges less than 10 microseconds. At 400 c/s there should be no evidence of differentiation. Switch to the "internal frequency modulation" position and check that the waveform is a clean triangular wave at both the maximum and minimum frequencies. Its amplitude should not be less than 200 volts at 400 c/s or less than 20 volts at 4 kc/s.

(j) Check the external reflector modulation. Link synch output socket to external reflector modulation socket. Waveform should be as in (i).

6. MAINTENANCE

6.1 Removal of Instrument Case

In the event of servicing becoming necessary, the instrument case should be removed as described below.

(a) Disconnect from the mains and remove the back panel.

(b) Lay the unit on its back so that the bottom of the case is accessible.

(c) Remove the stainless steel cover plate by unscrewing the two self-tapping screws underneath.

(d) Remove the four screws which secure the feet. The cover is now free and can be lifted off.

To reassemble the case, proceed as follows:

(a) Replace the back panel, leaving the screws loose.

(b) Lay the instrument on its back and slip the cover loosely into position.

(c) Replace the stainless steel cover plate.

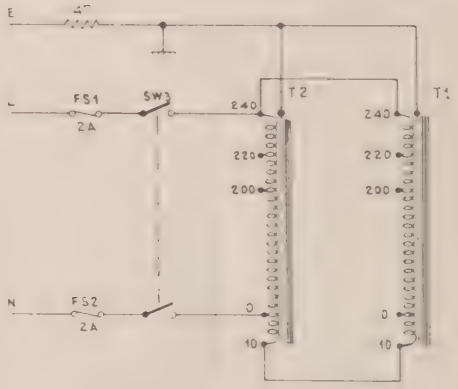
(d) Refit the feet, leaving the screws loose.

(e) Turn the unit on its face and make sure that the case is fully forward with the bezel close to the turned-over lip of the case.

(f) Press the sides of the case together and tighten the screws securing the feet, first at the back and then at the front. Tighten the back panel screws.

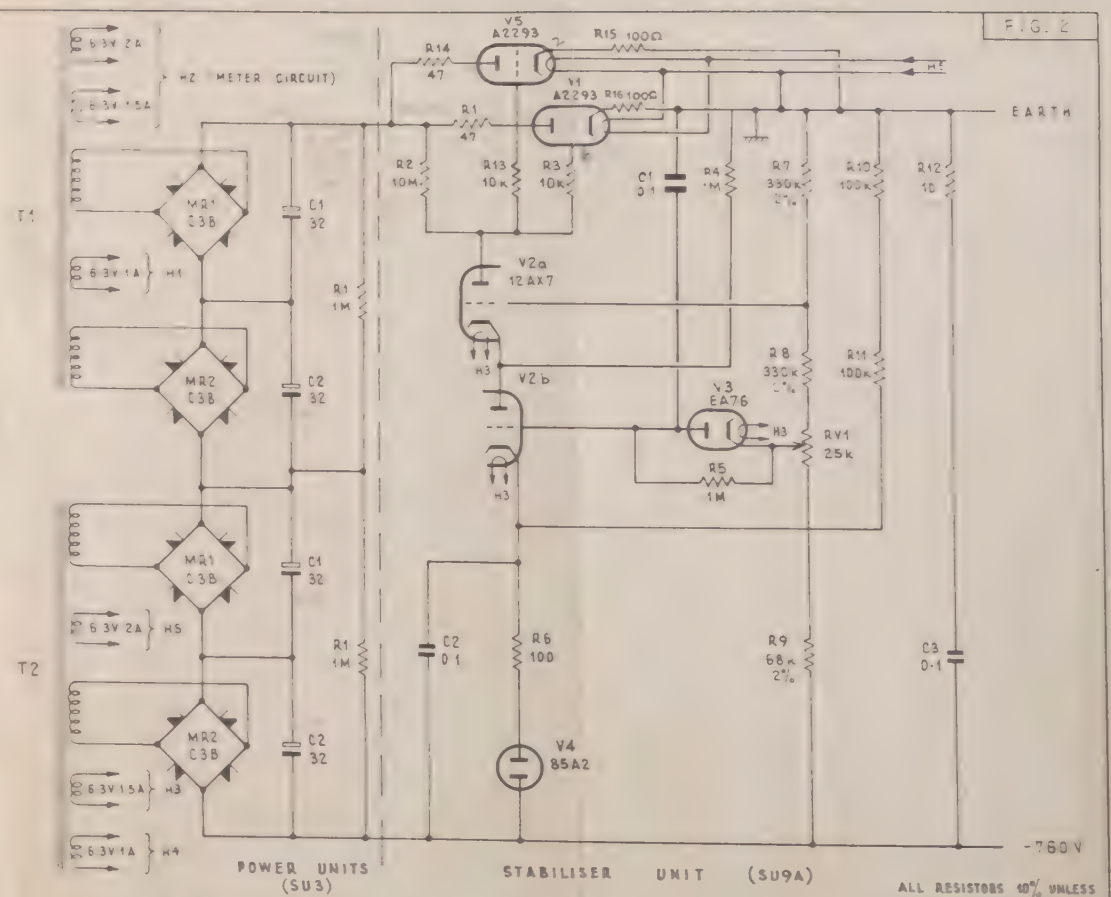
6.2 Electronic Circuits

Very little maintenance is required for the electronic circuits apart from occasionally blowing out dust and keeping the ventilation holes free. Fault finding is best carried out by following through the procedure outlined in Section 5. After repairing a fault, it is essential to carry out the whole of that procedure from the beginning.



MAINS CONNECTIONS

CONNECT MAINS INPUT TO 220V FOR 210-230V OPERATION



-760 VOLT D.C. SUPPLY

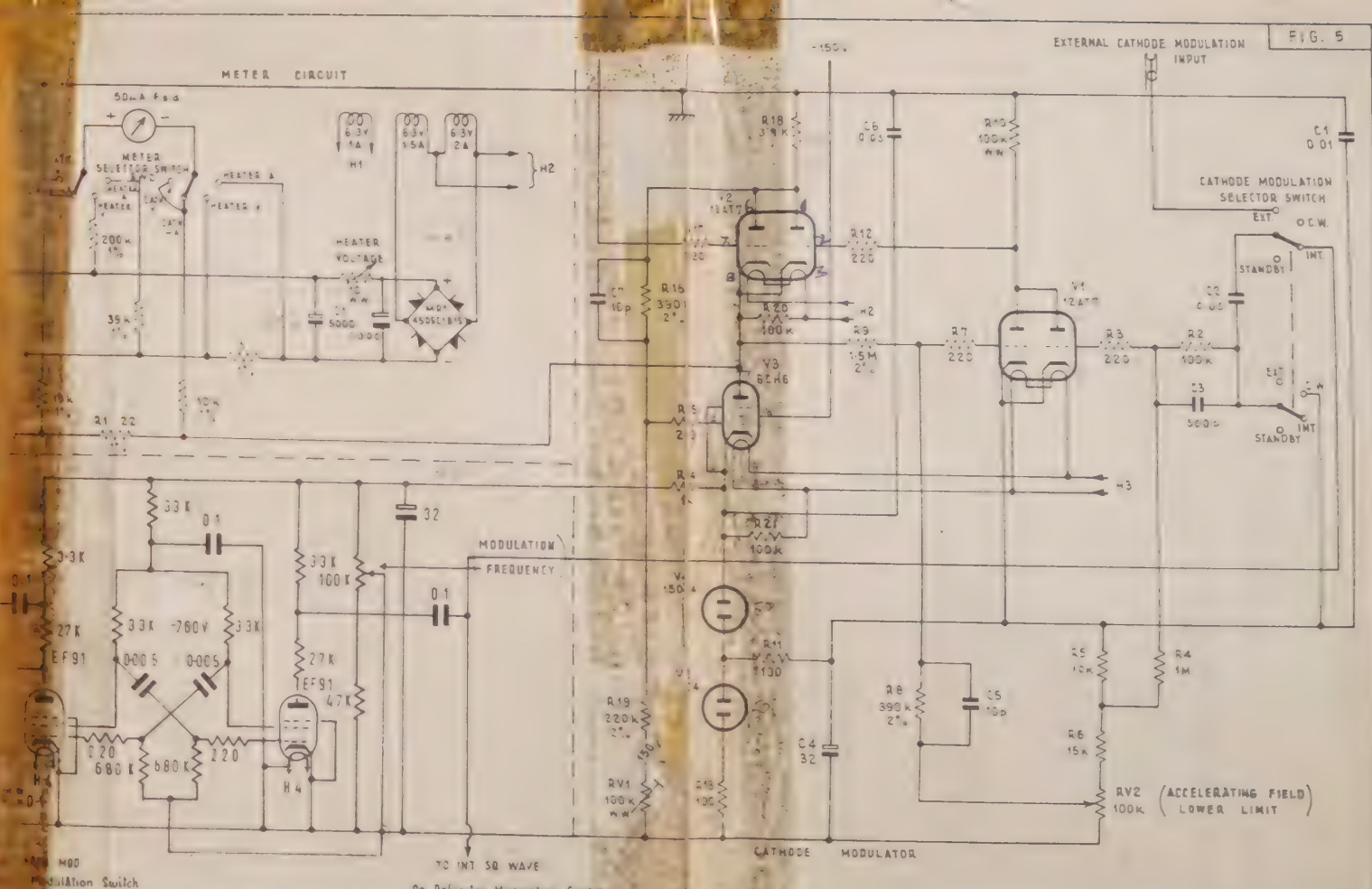
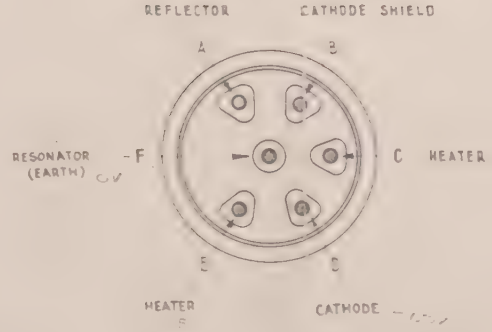


FIG. 5
METER CIRCUIT
50mA f.s.d
METER SELECTOR SWITCH
HEATER
HEATER VOLTAGE
6.3V 1A
6.3V 1.5A
6.3V 2A
H1
H2
H3
H4
EXTERNAL CATHODE MODULATION INPUT
CATHODE MODULATION SELECTOR SWITCH
EXT.
O.C.W.
INT.
STANDBY
MODULATION FREQUENCY
TO INT SQ WAVE On Reflector Modulation Switch
CATHODE MODULATOR
RV2 100K (ACCELERATING FIELD LOWER LIMIT)
METER CIRCUIT, SQUARE WAVE GENERATOR AND CATHODE MODULATOR

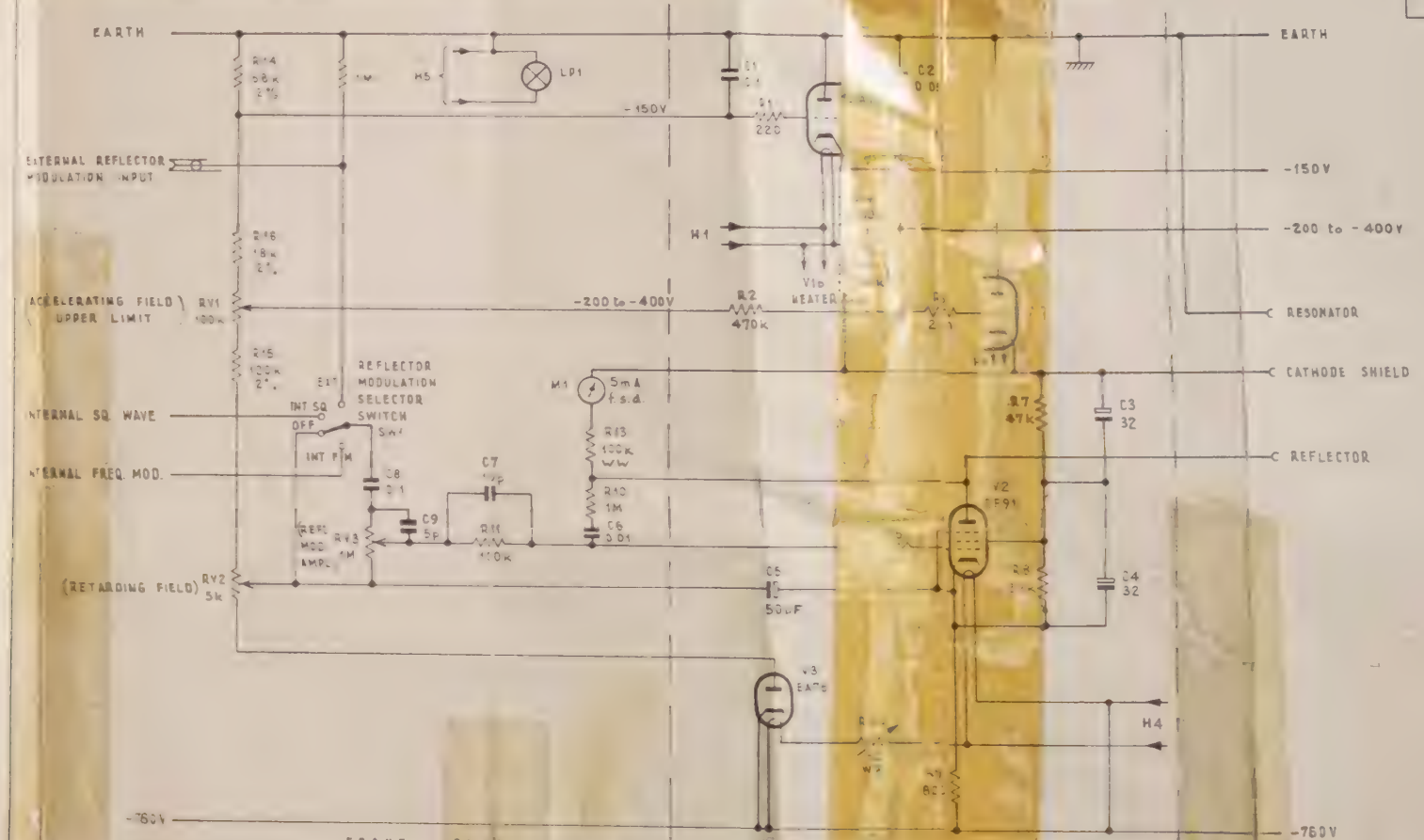


This lay-out not applicable to E700/753.
For [illegible] see Manual [illegible]

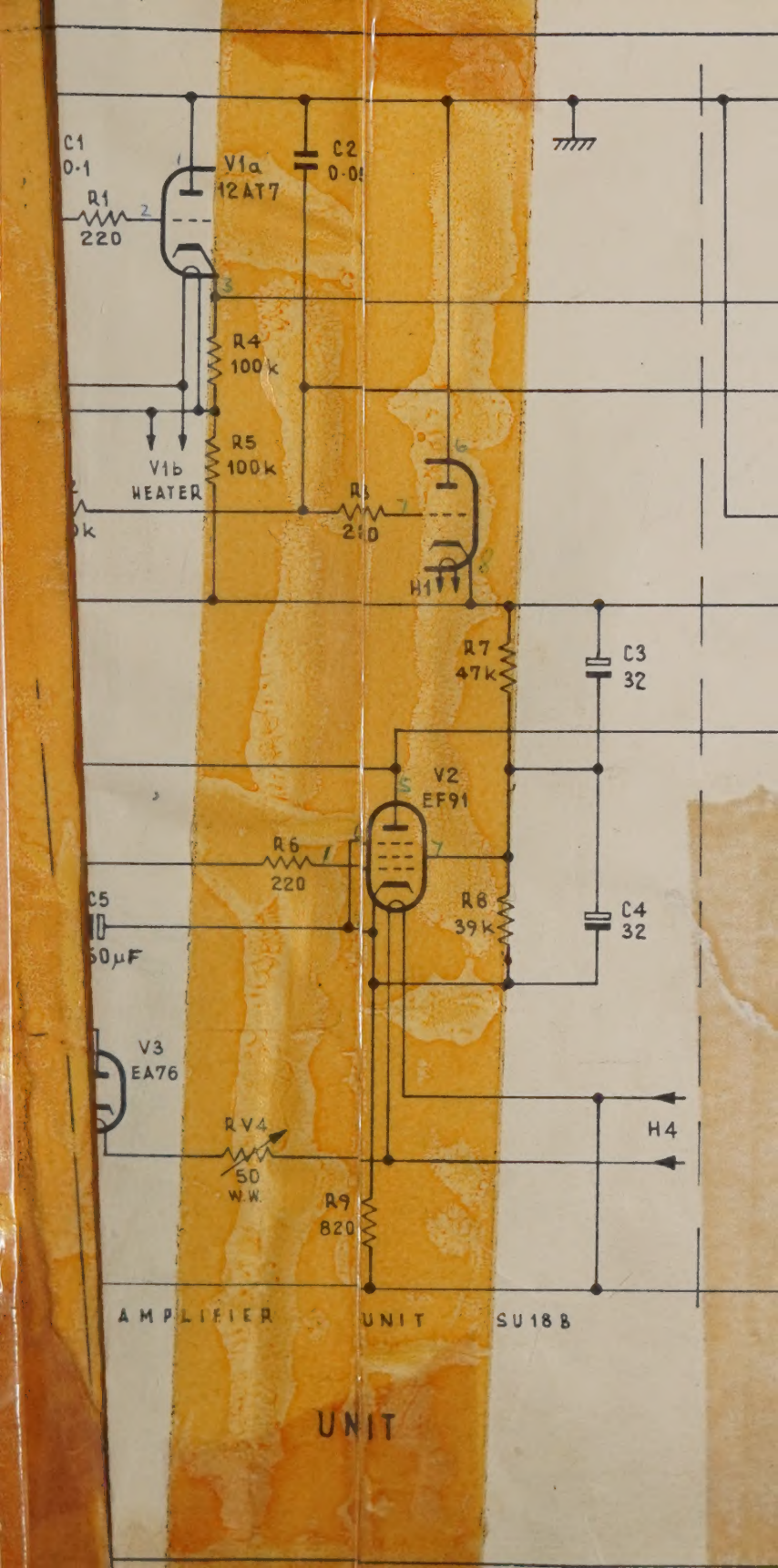
CONNECTIONS TO SOCKET ON FRONT PANEL

(VIEWED FROM FRONT)

FIG. 4



AMPLIFIER UNIT


C1
0·1
R1
220
V1a
12AT7
C2
0·05
R4
100k
R5
100k
V1b
HEATER
R3
H1
R7
47k
C3
32
V2
EF91
R6
220
C5
50µF
R8
39k
C4
32
V3
EA76
RV4
50
W.W.
R9
820
H4
AMPLIFIER UNIT SU18B
UNIT

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